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Social Network Analysis and L2 English Acoustic Vowel Space: A Case Study

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SOCIAL NETWORK ANALYSIS AND L2 ENGLISH ACOUSTIC VOWEL SPACE: A CASE STUDY

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ABSTRACT

We investigate the social network and the acoustic vowel space of a Mandarin Chinese speaker of English. Our goal is to test Krashen's Input Hypothesis, and determine whether or not the quality and quantity of input that our participant receives within his social network can help him to improve his pronunciation of English vowels. First, we did an audit of his vowels to find out which ones of the 11 monophthong vowels of English he can produce intelligibly and which ones he cannot. The informant was recorded producing these 11 phonemic vowels. The F1 and F2 correlates of these vowels are compared to those of General American English (GAE), as described by Peterson and Barney (1952). The acoustic thresholds used in Speech Intelligibility research are used to assess the informant's vowels that may interfere with intelligibility. The findings are used to suggest the appropriate course of action that the participant can follow to improve his pronunciation.

1.0 Introduction

Krashen (1985) makes the claim in his Input Hypothesis that in order for a second language learner to advance to a higher stage of language proficiency, there needs to be comprehensible input. He came up with the formula i + 1, which means that an L2 learner needs to be challenged by input which contains at least a small number of elements unfamiliar to the said learner. In addition to quantity of input, there must also be quality of input. This means that input from a native speaker of the target language is more likely to be beneficial, than input provided by a non-native speaker. In theory, therefore, the more native speakers an L2 learner has in his/her social network, the more likely he/she will receive quality input that can help him/her improve his/her pronunciation. In recent years, a lot of emphasis has been placed on pronunciation (phonetics and phonology) as a way of improving oral proficiency (Munro 2011: 9). This study seeks to examine the social network of a Mandarin speaker and make predictions on the basis of the participants in his social network about how much progress he is likely to make in oral proficiency. We limit our inquiry only to vowels.

2.0 Background Information about the Informant

The informant is a 22-year-old male from China, hereinafter referred to as Jason. Jason's first language is Mandarin Chinese. His second language is English, which he started learning in middle school. He stated that the English instruction that he received in middle school and college was not intensive, although English was a mandatory academic subject. In high school, he took the SAT (Scholastic Assessment Test), as well as other standardized tests. The preparations for these tests helped to improve his written English, but did not do much to improve his speaking abilities. However, his scores were good enough to be admitted as a graduate student at St. Cloud State University, in Saint Cloud, Minnesota where he has been living for a year and a half at the time of this study. He lives in a campus dormitory that has a policy of rooming non-domestic students with American students. The expectation is that this living arrangement will diversify the social network of international students. It is taken for granted

that the language input that L2 speakers of English receive from their native speaking roommates will improve their English proficiency. Jason rated his proficiency in English at the time of the interview and recording as intermediate. When asked what area of English he would most like to improve, he responded without hesitation speaking and writing.[1]

3.0 Social Network

The research questionnaires ask participants to list four individuals with whom they interact the most at the university. The four that make up Jason's social network are listed in Table 1. Jason spends about three hours a week with his Mongolian friend, Friend A, and three hours a week with his Chinese friend, Friend D. Mostly Mandarin is used when interacting with these two people, unless somebody who does speak Mandarin is present. If a non-Mandarin speaker is present, English is used. Friend B is a male from Minnesota whose first language is English. Friend C, Jason's roommate, is a Thai refugee who has been living in the United States for seven years. He is, for all practical purposes, a native speaker of English.

	Friend A	**Friend B**	**Friend C**	**Friend D**
Country	Mongolia	USA	Thailand/USA	China
L1	Mongolian	English	Thai	Mandarin
Interaction hrs/week	3	10+	10+	3
Context	Social	Social	Social/roommate	Social
Language used	Mandarin	English	English	Mandarin

Table 1: Jason's Social Network

Jason, Friend B, and Friend C form a strong network within the general network. A strong network is a network in which all members are equally linked (Wardaugh & Fuller, 2015:70-72). By definition, Jason's social network would be characterized as weak, which would mean that not all members of the network are equally linked; however, it is important to point out the strong linkage between three members, Jason, Friend B, and Friend C. All individuals listed by Jason have met each other and have interacted with each other at some point, thus making his social network dense. Lastly, Jason's network is simplex, as most members of the network almost exclusively know each other only in a social context. The diagram in Figure 1 represents these linkages. The dotted line represents the weak linkage between social network members who do not spend time together but have met each other. The thin solid line represents the linkage between Jason and his two friends with whom he only spends approximately 3 hours a week, respectively. Lastly, the bolded solid line represents the strong linkage between Jason, Friend B, and Friend C, with whom he spends over 20 hours per week.

[1] The participant signed an Institutional Review Board (IRB) informed consent form, which is on file with the second author.

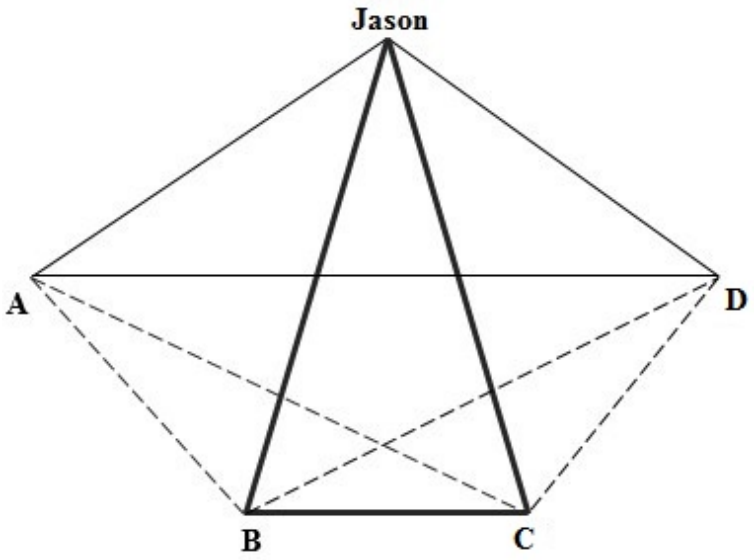

Figure 1: Jason's Social Network Diagram

3.1 Proficiency Predictions Based on Social Network

Based on the information in Table 1 and Figure 1, it can be predicted that Jason's English proficiency will improve at a fast pace. If we take into consideration the amount of interaction between the three members of the triangle within the network (Jason, Friend B, and Friend C), we can conclude that the informant has both quantity and quality of input, as two individuals in the triangle are native speakers of English. Jason constantly receives input from native speakers of the target language. Therefore, the informant is challenged by new linguistic input all the time.

4.0 Vowel System in Jason's L1

Standard Chinese Mandarin is believed to have five vowels, (Duanmu, 2005; Lin, 1989), but some (Lee & Zee, 2003) claim that it has one additional vowel, [ɤ]. As it can be seen in the vowel chart of Mandarin in Figure 2 below, [i] and [y] are high front vowels, and [u] and [ɤ] are high back vowels. According to Duanmu (2005:1), the mid vowel [ə] and the low vowel [a] become more or less fronted depending on the environments in which they occur.

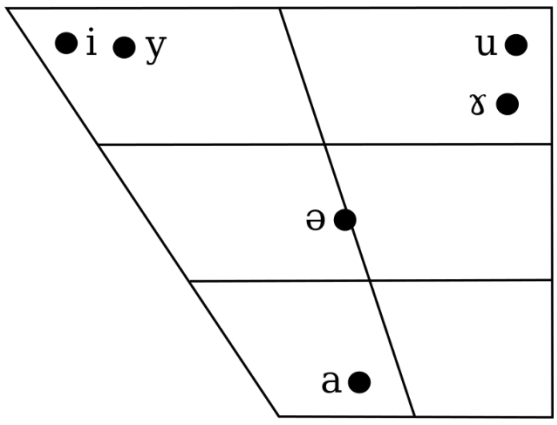

Figure 2: Standard Chinese Vowel Chart (Lee and Zee, 2003, p. 110)

There is a mismatch between English vowels and Standard Chinese Mandarin vowels. English has 11 vowels, while Standard Chinese Mandarin has only five or six vowels. It can be postulated on the basis of the discrepancy between the two vowel systems that Jason would have a hard time producing some English vowels. It can be further postulated that some of these vowels can cause varying degrees of unintelligibility. We test these hypotheses by analyzing the vowels that Jason actually produces when speaking English.

5.0 Acoustic Vowel Space

Jason was recorded pronouncing all 11 phonemic English vowels in the following words: <heed>, <hid>, <hayed>, <head>, <had>, <hod>, <hawed>, <hoed>, <hood>, <who'd>, and <hud>. He repeated each word three times. PRAAT, an open source software used in acoustic phonetic analyses was used to record and annotate the informant's vowels. Each vowel was measured for pitch/F0, F1, F2, F3, duration, and intensity. In 1952, Peterson and Barney measured American English vowels acoustically. Their measurements are deemed to be representative of General American English (GAE). It is against these values that Jason's vowels are compared and contrasted. The full set of spectrograms and measurements can be found in Appendix 1.

In assessing the intelligibility of vowels, the acoustic correlates that are deemed the most robust are F1 and F2. The former indicates tongue height, and the latter the horizontal front and back movements that the tongue makes. The most robust correlate is F1 because it alone contains 80% of the acoustic energy found in vowels (Ladefoged & Johnson, 2015:207). When F1 and F2 correlates are plotted in Norm, they provide us with an acoustic vowel space such as the one in Figure 3:

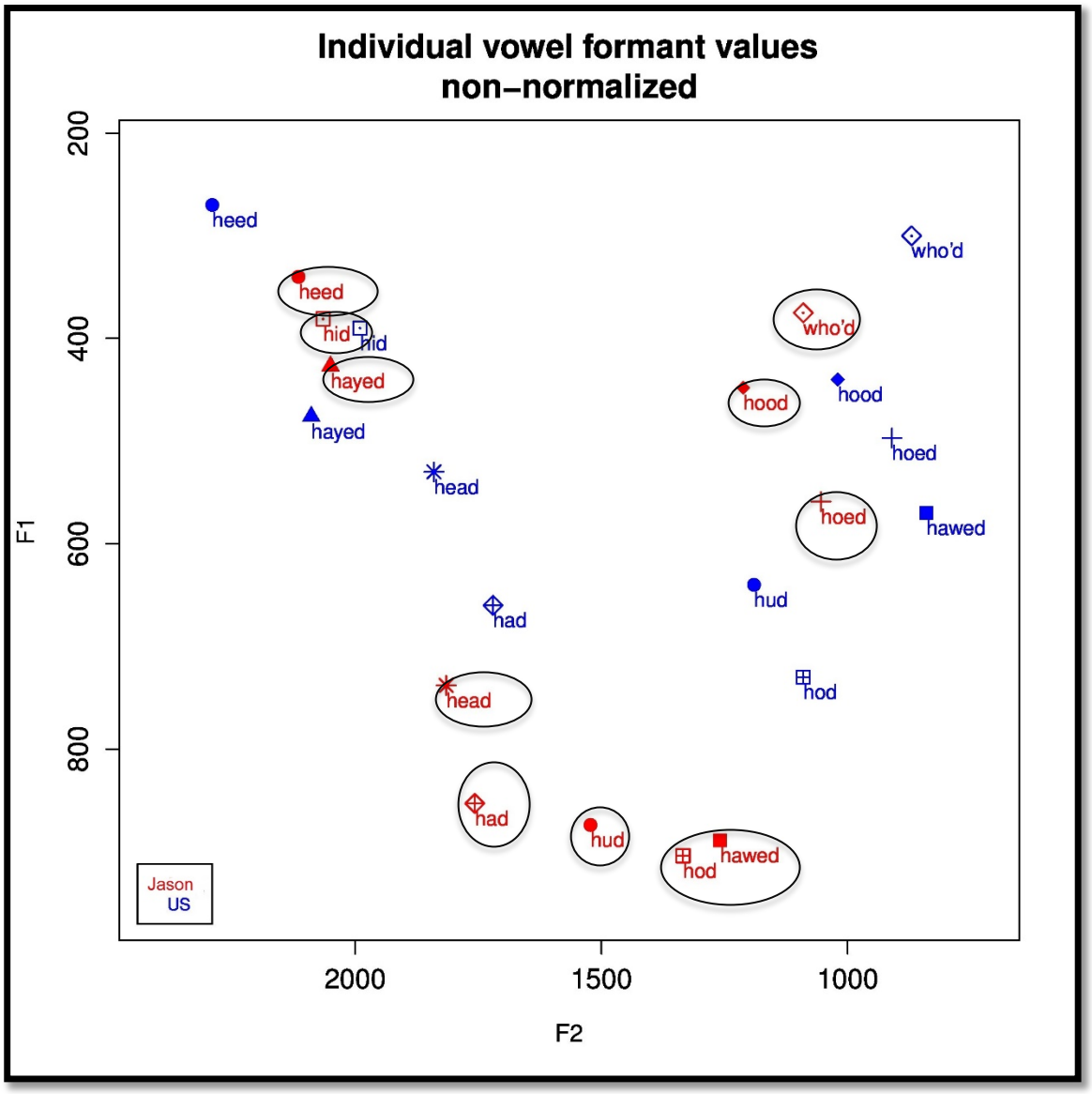

Figure 3: Jason's Vowel Space

Ladefoged and Johnson (2015:234) explains the usefulness of comparative acoustic vowel spaces such as the one in Figure 3 as follows:

> Any language will serve to provide known reference points. For example, when teaching English as a second language, one might use the vowels of the first language of the students as reference points for comparison with the dialect of English that one is trying to teach. If a chart of the vowels of this language is not available, then the instructor's first step should be to make one. This will involve either comparing the vowels of the language with vowel of some known language to the instructor for which there is a chart

available, or making a recording of the vowels of the language in question and analyzing them using a program such as WaveSurfer.[2]

This is precisely what we did with Jason's pronunciation of the 11 English monophthongs. Figure 3 helps us to visualize how L1 and L2 vowels fit together in the same vowel space. Jason's vowels are encircled in order to distinguish them from GAE vowels. Acoustic vowel spaces such as the one in Figure 3 are used in tandem with measurements such as those in Table 2 to determine the degrees of masking that may be responsible for unintelligibility.

Words		heed	hid	hayed	head	had	hod	hawed	hoed	hood	who'd	hud
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
GAE	F1	270	390	*476	530	660	730	570	*497	440	300	640
GAE	F2	2290	1990	*2089	1840	1720	1090	840	*910	1020	870	1190
Jason	F1	340	381	427	738	853	904	889	559	448	375	874
Jason	F2	2115	2065	2050	1815	1757	1334	1259	1054	1212	1090	1522

Table 2: F1 and F2 Measurements

Koffi (2016:105) has proposed the scale in Table 3 to gauge the intelligibility of vowels instrumentally. If the acoustic distance between two adjacent vowels is less than 20 Hz, it means that they mask each other completely and cause complete unintelligibility. If the acoustic distance is between 21 and 40 Hz, unintelligibility is likely, but contextual cues may alleviate confusion. From 41 to 60 Hz, unintelligibility is minimum. If the acoustic distance is over 61 Hz, the two vowels are perceived distinctly.

Acoustic Distance between Phonemes	Unintelligibility/Confusion
≤ 20 Hz	Absolute
21-40 Hz	Moderate
41-60 Hz	Minimum
≥ 61 Hz	No Confusion: 100% Intelligibility

Table 2: F1 Measurements and Intelligibility

Now, let's apply these thresholds to Jason's accented-English vowels to see which ones are more likely to cause unintelligibility. There are four such vowels. The first pair of vowels that are problematic is [o] versus [ɔ]. Jason's [o] (559 HZ) masks [ɔ] (570 Hz) in GAE. Unintelligibility is absolute because the acoustic distance between the two is only 11 Hz. This is surprising because, according to Figure 2, Mandarin does not have the vowels [o] and [ɔ]. As a result, Jason does not distinguish between these two vowels clearly. If Jason produces <oat>, GAE hearers may perceive it as <ought>, and vice versa. The second challenging pair is [ʌ] versus [ɔ]. Jason pronounces them identically. His [ʌ] (874 Hz) and [ɔ] (889 Hz) mask each other because the acoustic distance between them is only 15 Hz because they are perceptually indistinguishable. Thirdly, the difference between [ʌ] and [ɑ] is barely perceptible. Jason does not distinguish clearly between his [ɑ] (904 Hz) and his [ʌ] (874 Hz). The acoustic distance between them is 30 Hz. Lastly, [ʌ] (874 Hz) differs from [æ] (853 Hz) by only 21 Hz. In other

[2] We used Praat instead of WaveSurfer.

words, if Jason produces the words <coat>, <caught>, <cut>, and <cat>, GAE hearers would have a hard time distinguishing between them accurately.[3]

The relative functional load (RFL) that individual vowels carry in relation to other vowels is a good predictor of the severity of unintelligibility when they mask each other acoustically. Catford (1987: 87-89) notes that the RFL between [o] and [ɔ] is 88%. This means that each time that these two vowels are switched, there is a very high likelihood of unintelligibility. The RFL of [æ] and [ʌ] is 68%. This means that when they are substituted for each other, unintelligibility is high, 68%. The RFL of [ɑ] and [ʌ] is also high, 65%. The vowels that Jason has a hard time distinguishing all have high RFLs. This means that these vowels may make it hard for GAE hearers to understand Jason very well. Maybe Jason is aware of this situation. That would explain why the two English skills on his wish list are improving his oral skills and his writing skills. All segments are important for intelligibility, but Prator and Robinett (1985:13) single out vowels specifically for non-native speakers. They give the following piece of advice to would-be learners and their teachers, "If you wish to understand and be understood in English, you must be able to distinguish and make the distinction among the vowel sounds with accuracy."

6.0 Conclusion

Jason wants to improve his speaking and his writing. The latter is not addressed because it is outside the scope of this paper. As for the former, our analysis indicates that Jason must endeavor to distinguish the following pairs [o] vs. [ɔ], [ʌ] vs. [ɔ], and [æ] and [ʌ] accurately if he wishes to improve the intelligibility of his speech. A copy of the vowel audit was made available to Jason so that he can use it as a roadmap for improving his pronunciation. He was encouraged to share our findings with Friends B and C so that they can help him with these vowels. Jason was also asked to pay close attention to the words that the two native speakers of English in his social network produce that contain these challenging vowels. He can imitate these words in his head or he can imitate them audibly and give his friends permission to correct his pronunciation. If he takes these initiatives and monitors his pronunciation of these challenging vowels, his oral skill will continue to improve. It is quite likely that the vowels contained in the new words that he is learning from Friends B and C and other native/proficient speakers on campus will be produced intelligibly. However, the vowels [o, ɔ, ʌ, æ] found in words that he acquired prior to his coming to the US may still be problematic because of fossilization.

[3] There are additional characteristics of Jason's vowels. However, since they do not interfere with intelligibility, we do not discuss. We note in passing that his [e] and [ɪ] are higher than their counterparts in GAE. His back vowels are slightly fronted.

ABOUT THE AUTHORS

Martina Abat is a graduate student in the MA TESL program and Introduction to Linguistics Teaching Assistant at St. Cloud State University, St. Cloud, Minnesota. She was born and raised in Montenegro, Europe. At the University of Montenegro, she earned her BA in English language and Literature. Martina spent her second year of college as an exchange student at St. Cloud State University, where her interest in linguistics and laboratory phonetics intensified. This was the reason behind her decision to come back to St. Cloud State University for her MA.

Ettien Koffi is a professor of Linguistics. He teaches the linguistics courses in the TESL/Applied Linguistics MA program in the English Department at Saint Cloud State University, MN. He has written three linguistic books: *Language Society in Biblical Times* (1996), *Paradigm Shift in Language Planning and Policy: Game Theoretic Solutions* (2012), and *Applied English Syntax* (2015). He is the author of many peer-reviewed articles on various topics in linguistics. His primary area of specialization is at the interface between acoustic phonetics and phonology. He has extensive experience in emergent orthographies and in the acoustic phonetic and phonological description of dialect variation. He can be reached via email at: *enkoffi@stcloudstate.edu*.

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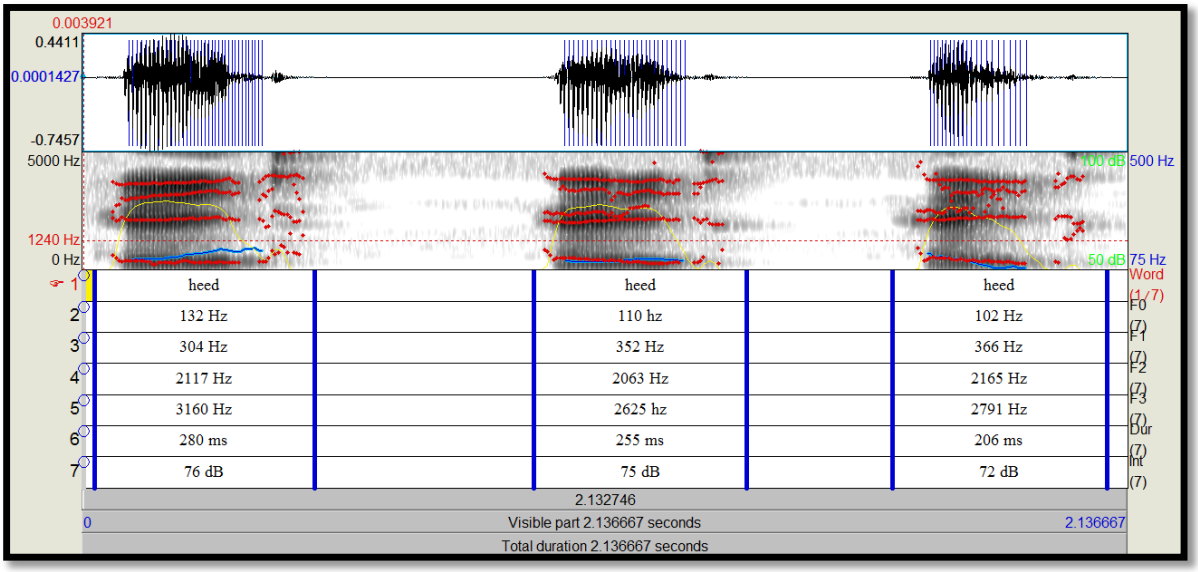
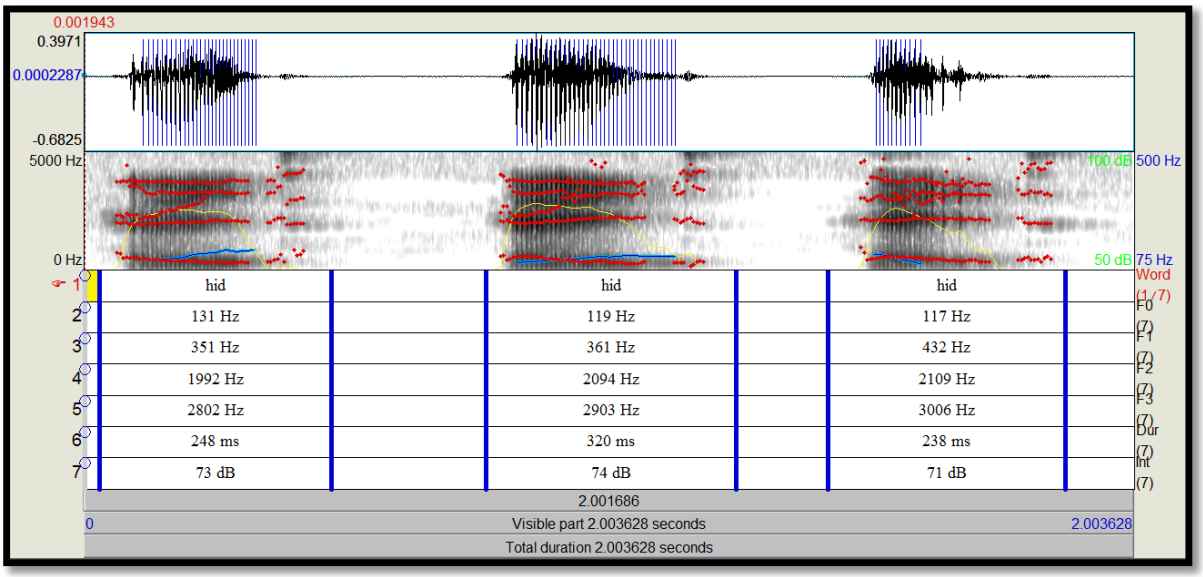
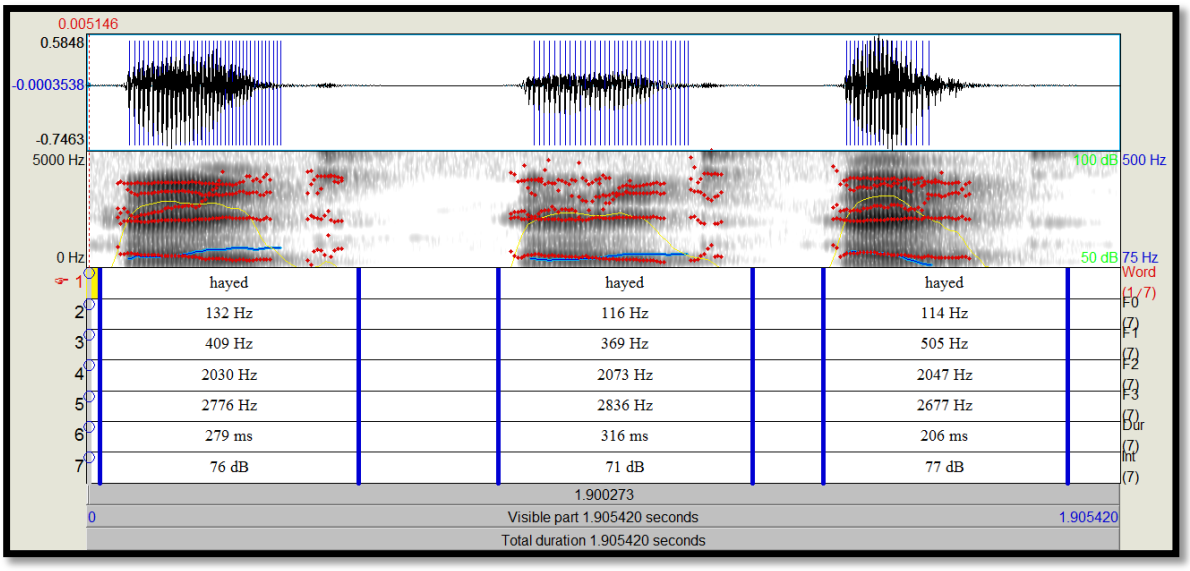
Appendix 1



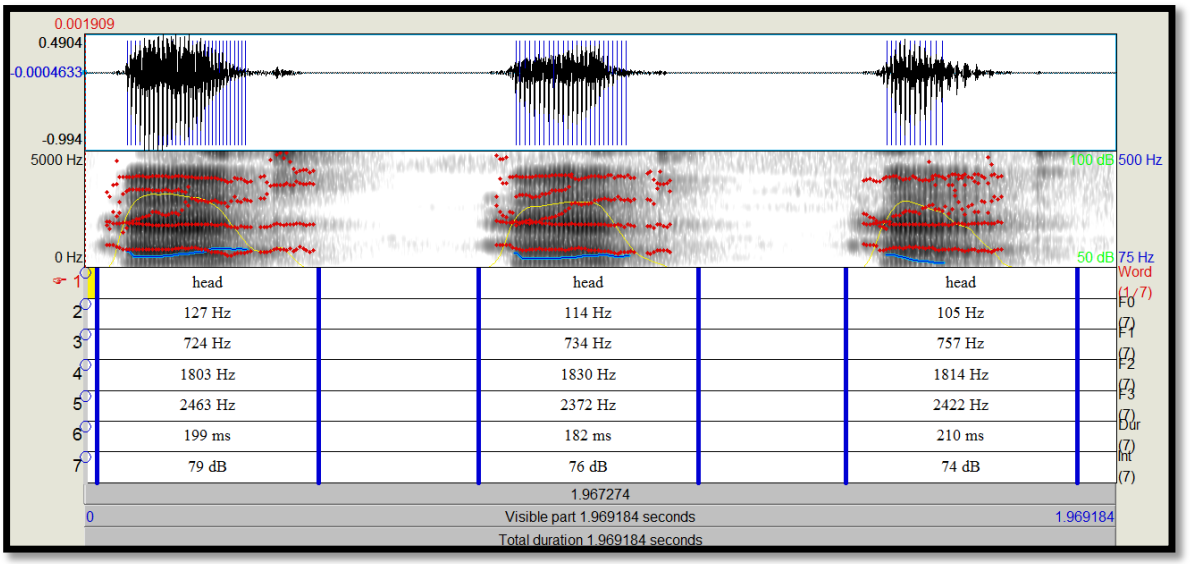
	<heed> [i]	F0	F1	F2	F3	Duration	Intensity
Mean		114	340	2115	2858	247	74



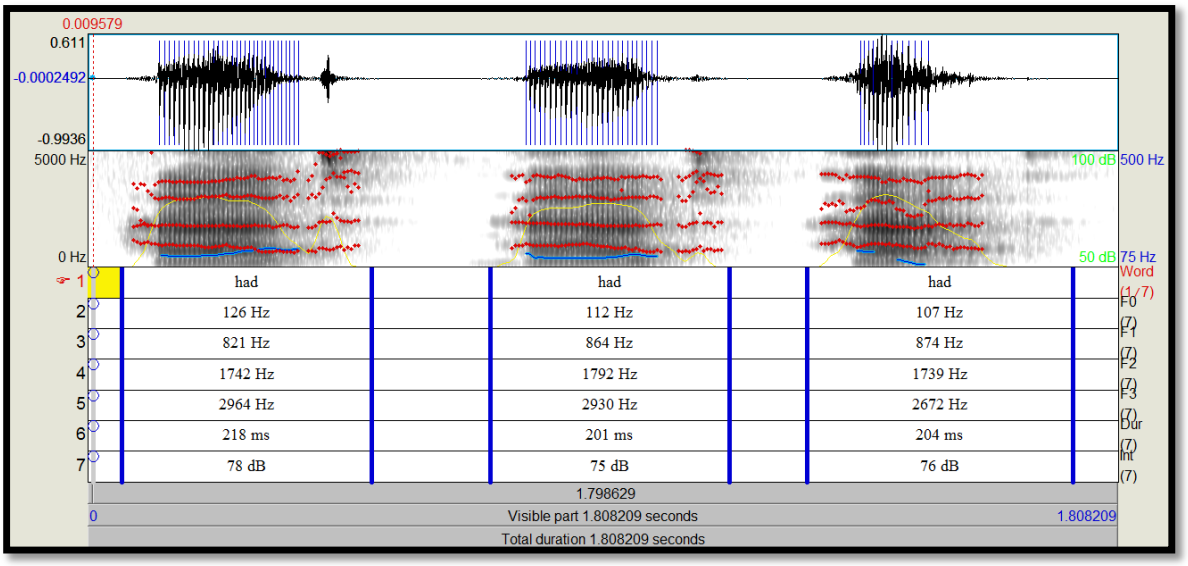
	<hid> [ɪ]	F0	F1	F2	F3	Duration	Intensity
Mean		122	381	2065	2903	268	72



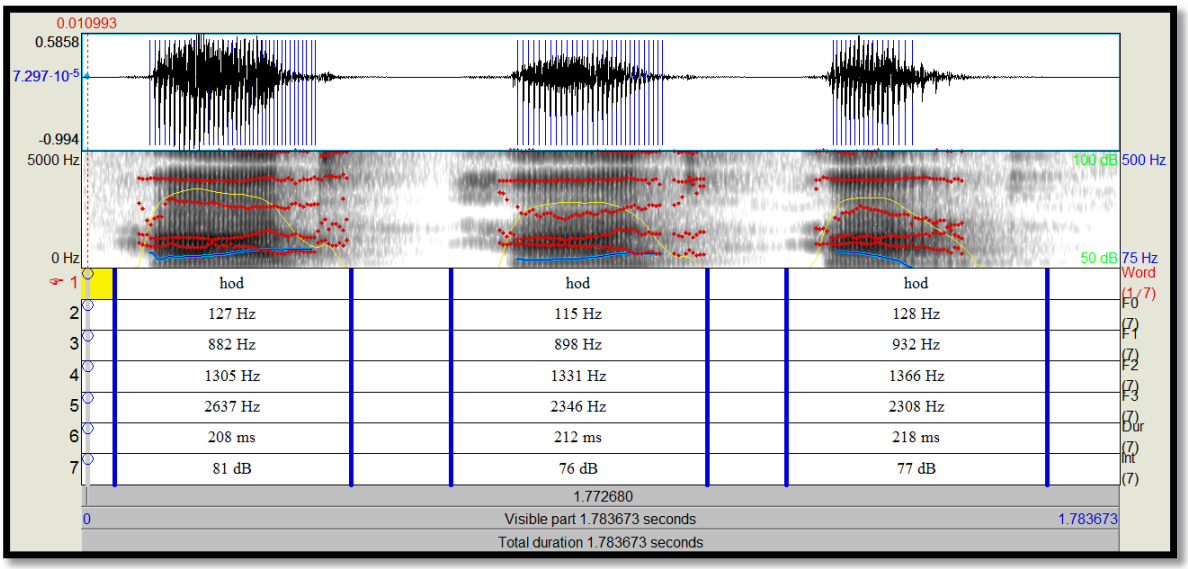
	<hayed> [e]	F0	F1	F2	F3	Duration	Intensity
Mean		120	427	2050	2763	267	74



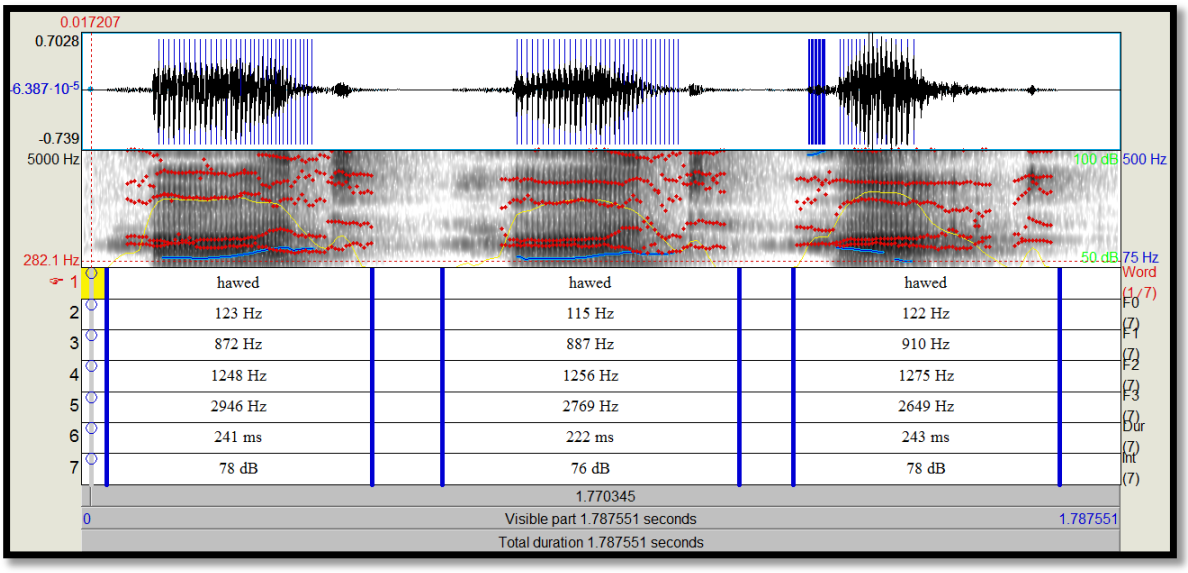
	<head> [ɛ]	F0	F1	F2	F3	Duration	Intensity
Mean		115	738	1815	2419	197	76



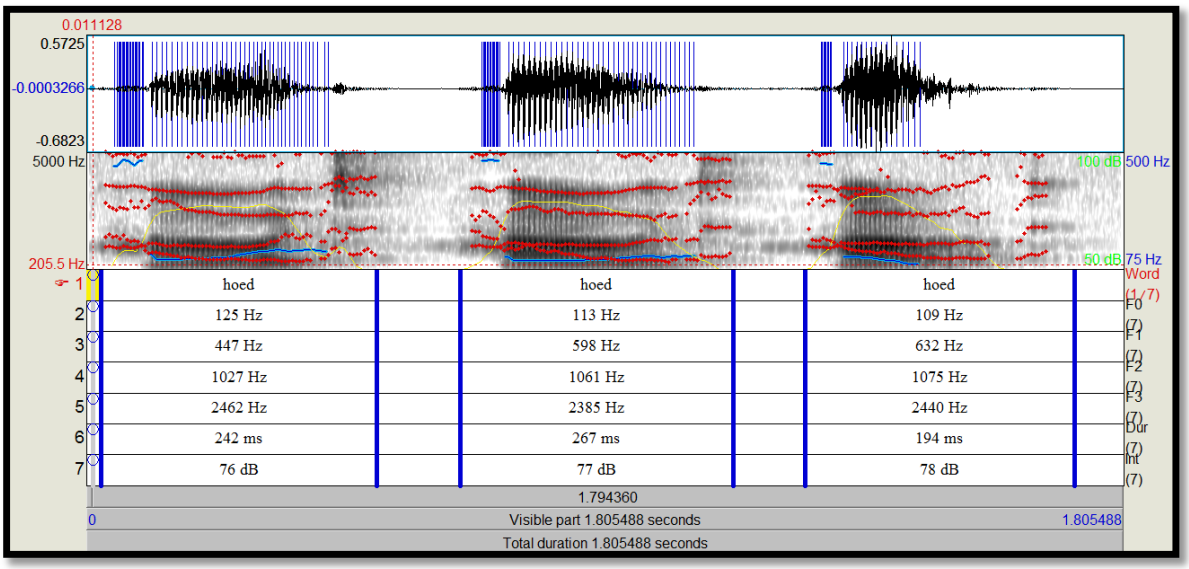
	<had> [æ]	F0	F1	F2	F3	Duration	Intensity
Mean		115	853	1757	2855	207	76



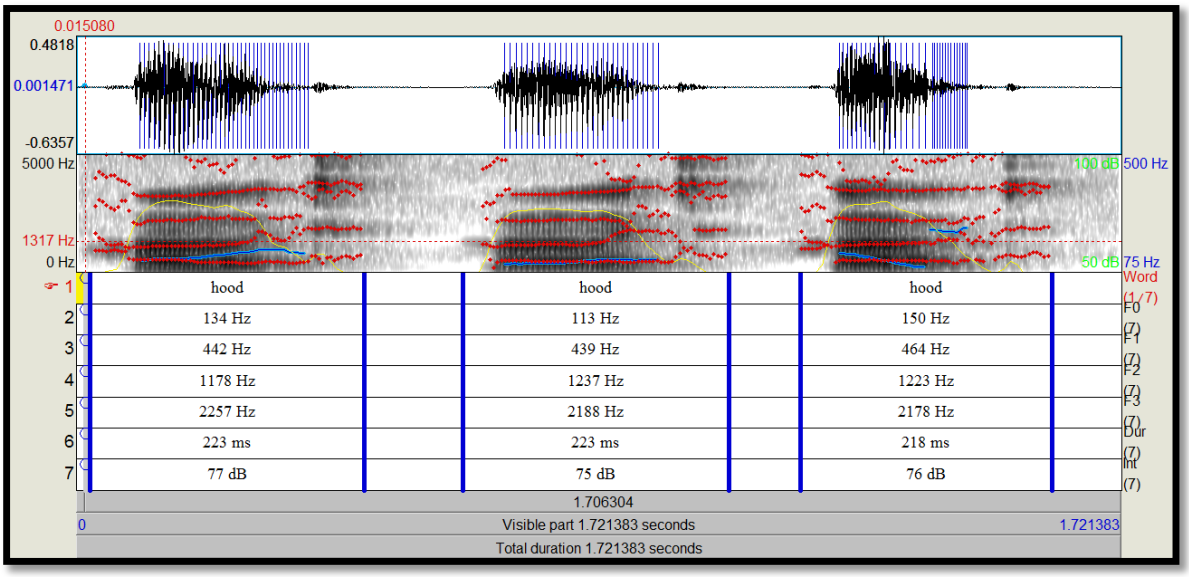
	<hod> [ɑ]	F0	F1	F2	F3	Duration	Intensity
Mean		123	904	1334	2430	212	78



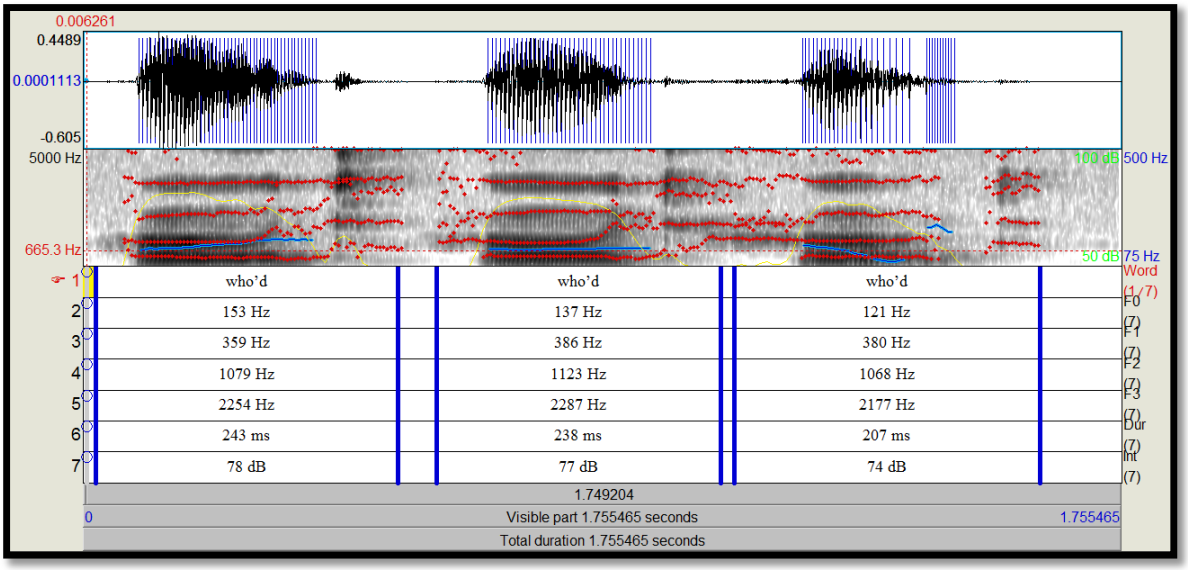
	<hawed> [ɔ]	F0	F1	F2	F3	Duration	Intensity
Mean		120	889	1259	2788	235	77



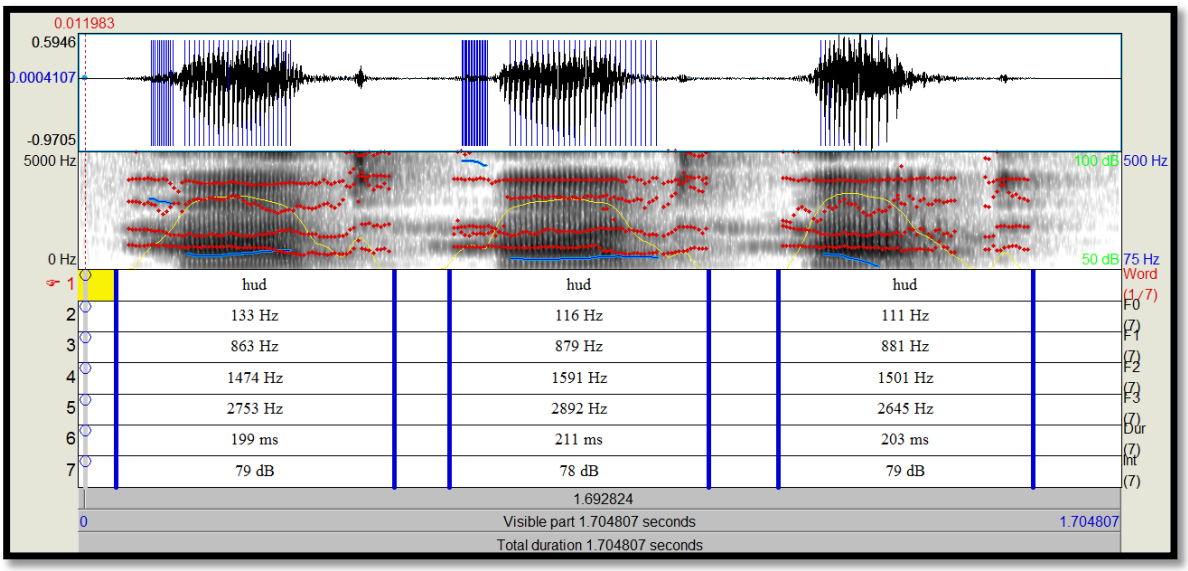
	<hoed> [o]	F0	F1	F2	F3	Duration	Intensity
Mean		115	559	1054	2429	234	77



	<hood> [ʊ]	F0	F1	F2	F3	Duration	Intensity
Mean		132	448	1212	2207	221	76



	<who'd> [u]	F0	F1	F2	F3	Duration	Intensity
Mean		137	375	1090	2239	229	76



	<hud> [ʌ]	F0	F1	F2	F3	Duration	Intensity
Mean		120	874	1522	2763	204	78

Overall Measurements

Words		heed	hid	hayed	head	had	hod	hawed	hoed	hood	who'd	hud
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
GAE	F0	136	135	NA	130	127	124	129	NA	137	141	130
GAE	F1	270	390	*476	530	660	730	570	*497	440	300	640
GAE	F2	2290	1990	*2089	1840	1720	1090	840	*910	1020	870	1190
GAE	F3	3010	2550		2480	2410	2440	2410		2240	2240	2390
MidW	F0	138	135	129	127	123	123	121	129	133	143	133
MidW	F1	342	427	476	580	588	768	652	497	469	378	623
MidW	F2	2322	2034	2089	1799	1952	1333	997	910	1122	997	1200
MidW	F3	3000	2684	2691	2605	2522	2538	2538	2459	2434	2343	2550
DUR		243	192	267	189	278	267	283	265	192	237	188
Jason	F0	114	122	120	115	115	123	120	115	132	137	120
Jason	F1	340	381	427	738	853	904	889	559	448	375	874
Jason	F2	2115	2065	2050	1815	1757	1334	1259	1054	1212	1090	1522
Jason	F3	2858	2903	2763	2419	2855	2430	2788	2429	2207	2239	2763
Jason	Dur	247	268	267	197	207	212	235	234	221	229	204
Jason	Int	74	72	74	76	76	78	77	77	76	76	78